REMARKS

Claims 24-46 remain in this application. Claims 32-46 are withdrawn from consideration. Claims 24-31 are rejected. Claims 24-31 are amended herein to clarify the invention, to broaden language as deemed appropriate and to address matters of form unrelated to substantive patentability issues.

Applicants herein traverse and respectfully request reconsideration of the rejection of the claims cited in the above-referenced Office Action.

Applicants submit herewith a substitute specification and abstract wherein amendments are effected to place the text thereof into proper English in accordance with 37 CFR 1.125(c), to add headings and remove cites to claims. Also accompanying this amendment is a reproduction of the original specification with markings indicating the amendments effected in the substitute specification in accordance with MPEP §608.01(q) and 37 CFR 1.125(b). No new matter is added. Entry of the substitute specification and abstract is respectfully requested.

Claims 24-31 are rejected as indefinite under 35 U.S.C. § 112, second paragraph, for failing to particularly point out and distinctly claim the subject matter of the invention as a result of informalities stated in the Office Action. The claims are amended to remove or correct the informalities noted in the Office Action.

Therefore, reconsideration of the rejection of claims 24-31 and their allowance are earnestly requested.

Claims 24-26 and 28-31 are rejected as obvious over Razi et al. (US 5,417,904) under 35 U.S.C. §103(a). The applicants herein respectfully traverse this rejection. For a rejection under 35 U.S.C. §103(a) to be sustained, the differences between the features of the combined references and the present invention must be obvious to one skilled in the art.

It is respectfully submitted that a *prima facie* case of obviousness has not been established in the rejection of claims 24-26 and 28-31. "To establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine the reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, and not based on the applicant's disclosure. *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991)." MPEP §706.02(j) "Contents of a 35 U.S.C. §103 Rejection".

Razi et al. teaches a composite material comprising a melted thermoplastic polymer in which solid particulate wood is added merely as a filler. As such the

wood is dispersed as <u>particulate wood</u> throughout the melted polymer carrier (see the various steps of claim 1). Consequently, when such mixture of melted polymer solidifies, it cannot physically have the properties of claimed solidified wood melts ← lack sup (resulting from the melting of the wood itself and not just a thermoplastic carrier in which wood is dispersed as solid particles), but rather, would necessarily demonstrate the entirely different properties of a thermoplastic polymer in which particulate wood filled is dispersed.

As such, the reference fails to teach or suggest all the claim limitations as properly required to establish a *prima facie* case of obviousness. Therefore, reconsideration of the rejection of claims 24-26 and 28-31 and their allowance are respectfully requested.

Claim 27 does not appear to have been substantively rejected, and therefore applicants have not specifically addressed the subject matter thereof. It, however, derives patentability at least in part from claim 24, from which it depends, as well as for the additional recitations it contains.

For the convenience of the Examiner, APPENDIX II is provided herewith having a complete set of pending claims with all amendments effected therein.

Applicants respectfully request a two (2) month extension of time for responding to the Office Action. Please charge the fee of $410 for the extension of time to Deposit Account No. 10-1250.

In light of the foregoing, the application is now believed to be in proper form for allowance of all claims and notice to that effect is earnestly solicited. Please charge any deficiency or credit any overpayment to Deposit Account No. 10-1250.

Respectfully submitted,
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enc: Substitute Specification; and Marked reproduction of original specification.

APPENDIX I

AMENDED CLAIMS WITH AMENDMENTS INDICATED THEREIN
BY BRACKETS AND UNDERLINING

24. A wood component, comprising:

an article of wood including [in which the wood has] altered properties in geometrically defined near-surface areas as compared with an original state of the wood, [characterized in that] said geometrically defined near-surface areas [have the] having properties of solidified wood melts substantially free from pyrolytic degradation products.

25. A wood component [Component] according to Claim [1] 24, wherein [characterized in that] the geometrically defined near-surface areas [are] include cell walls melted in one or several cutting directions so that [the] a diffusion resistance in said geometrically defined areas to ambient media [rises] is greater relative to that of the original state of the wood independent of the cutting direction.

26. A wood component [Component] according to Claim 24 or 25, wherein [characterized in that] said geometrically defined near-surface areas are visually different from non-melted wood [in their] in the original state with respect to optical properties, absorptivity, reflectivity and diffusing power, and thereby [hence], luster.

27. A wood component [Component] according to Claim 24 or 25, wherein [characterized in that] the geometrically defined near-surface areas have a higher hardness and abrasion resistance than non-melted wood in the original state.

28. A wood component [Component] according to Claim 24 or 25, wherein a [characterized in that the] deformation behavior in the geometrically defined near-surface areas is altered compared with [the] non-melted wood in the original state.

29. A wood component [Component] according to Claim 24 or 25, wherein [characterized in that the] a bulk of the solidified wood melt is in a geometrically defined area of the wood component below [the] a surface thereof.

30. A wood component [Component] according to Claim 24 or 25, wherein [characterized in that the] at least one of physical [and/or] chemical properties of the geometrically defined near-surface areas [are] is altered from the original state by substances incorporated into the solidified wood melt.

31. A wood component [Component] according to Claim [24 or 25] 30, wherein [characterized in that] the incorporated substances are at least one of particles [and/or] and pigments.

APPENDIX II

ALL PENDING CLAIMS WITH AMENDMENTS EFFECTED THEREIN

24. (Amended) A wood component, comprising:

an article of wood including geometrically defined near-surface areas having altered properties as compared with an original state of the wood, said geometrically defined near-surface areas having properties of solidified wood melts substantially free from pyrolytic degradation products.

25. (Amended) A wood component according to Claim 24, wherein the geometrically defined near-surface areas include cell walls melted in one or several cutting directions so that a diffusion resistance in said geometrically defined areas to ambient media is greater relative to that of the original state of the wood independent of the cutting direction.

26. (Amended) A wood component according to Claim 24 or 25, wherein said geometrically defined near-surface areas are visually different from non-melted wood in the original state with respect to optical properties, absorptivity, reflectivity and diffusing power, and thereby, luster.

27. (Amended) A wood component according to Claim 24 or 25, wherein the geometrically defined near-surface areas have a higher hardness and abrasion resistance than non-melted wood in the original state.

28. (Amended) A wood component according to Claim 24 or 25, wherein a deformation behavior in the geometrically defined near-surface areas is altered compared with non-melted wood in the original state.

29. (Amended) A wood component according to Claim 24 or 25, wherein a bulk of the solidified wood melt is in a geometrically defined area of the wood component below a surface thereof.

30. (Amended) A wood component according to Claim 24 or 25, wherein at least one of physical chemical properties of the geometrically defined near-surface areas is altered from the original state by substances incorporated into the solidified wood melt.

31. (Amended) A wood component according to Claim 30, wherein the incorporated substances are at least one of particles and pigments.

32. Method for producing a wood component of Claim 24 or 25 characterized in that a locally limited or full-area contact-free short-time high energy input into the wood component occurs by electromagnetic waves, whereby a proportion of melted volume of geometrically defined magnitude at or below the surface of the component is produced with the energy input dimensioned such that the proportion of melted volume is produced without pyrolytic degradation processes.

33. Method according to Claim 32 characterized in that electromagnetic waves in form of laser light are used.

34. Method according to Claim 32 characterized in that the duration of the energy input is up to 50 ms.

35. Method according to Claim 32 characterized in that the energy input is carried out through electromagnetic radiation that can be controlled extremely

accurately and quickly regarding the lateral extension of the range of interaction, time of interaction and intensity, having a wavelength adapted to the desired depth of the range of interaction.

36. Method according to Claim 32 characterized in that the process is carried out under inert gas.

37. Method according to Claim 32 characterized in that the process is carried out in free atmosphere, i.e. in free air, at room temperature and normal atmospheric pressure.

38. Method according to Claim 32 characterized in that extraneous substances are incorporated into the geometrically defined areas by the melting process.

39. Method according to Claim 35 characterized in that the depth, or thickness of the range of interaction, respectively, according to the objective of the processing action is adjusted by selection of the wavelength, or range of wavelength, respectively, and the power density of the electromagnetic radiation as well as the time of interaction between the electromagnetic waves and the geometrically defined areas.

40. Method according to Claim 39 characterized in that the lateral extenson of the range of interaction, the time of interaction and the intensity are realized by combination of the relative motion between the beam and the workpiece as well as by methods of dynamic beam forming and beam focusing.

41. Method according to Claim 33 characterized in that the energy input is carried out using a pulse-type laser.

42. Method to Claim 41 characterized in that the time of interaction between the laser beam and the geometrically defined areas is equivalent to the pulse length of the laser.

43. A plurality of components of Claim 24 or 25 characterized in that said components having a melted area are joined with each other by the solidified wood melt free of pyrolytic degradation products.

44. A product characterized in that a wood-free material is joined with said component having a melted area of Claim 24 or 25, by the solidified wood melt free of pyrolytic degradation products.

45. A product according to Claim 44 characterized in that the wood-free material is at least one of transparent polymers and fibrous materials.

46. A product according to claim 20 characterized in that particles or pigments are incorporated into the solidified wood melt free of pyrolytic degradation products.

ABSTRACT OF THE DISCLOSURE

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A wood component includes geometrically defined areas in which the wood has altered properties of solidified wood melts which are substantially free from pyrolytic degradation products. A process for producing such components utilizes contact-free, short-time, high energy input to limit pyrolytic degradation processes.

SUBSTITUTE SPECIFICATION

F-6485 Ser. No. 09/509,808

WOOD COMPONENT AND A METHOD FOR THE PRODUCTION OF THE SAME

BACKGROUND OF THE INVENTION

The invention relates to a wood component in which the wood has altered properties in geometrically defined areas. The invention also relates to a method for producing such components and to the application of said component. The invention can be employed in the woodworking and wood processing industries, in the building and construction industries, and in the craft and trade.

In woodworking, lasers are used for, in addition to surveying processes, cutting and piercing processes. A novel application field is the removal of material using laser irradiation. Seltman, J.: Freilegen der Holzstruktur durch UV-Bestrahlung (Laying bare of the wood structure by UV-irradiation), Holz als Roh- und Werkstoff, Springer-Verlag, 53(1995), pp. 225–228; and Panzner, M. et al.: Experimental Investigation of the Laser Ablation Process on Wood Surfaces, Fourth International Conference on Laser Ablation COLA, Monterey, California, 1997, describe different possibilities and methods for the removal of the wood layer spoiled by mechanical removing processes using electromagnetic beams of different wavelengths.

From DE 94 02 681.5 U1, a device is known for the processing of glass, plastics, semiconductors, wood or ceramics, which uses laser radiation from a laser radiation source that emits laser radiation in the form of a laser beam, focusing this laser radiation through a focusing optical system onto a glass, plastic, semiconductor, wood or ceramic material component. This device is characterized in that the laser radiation used has a wavelength of 1.4 μm to 3.0 μm.

This device is designed to enable an effective removing mechanism which is designed to heat the material to be processed very heavily in the range of wavelengths of 1.4 μm to 3.0 μm so that so-called micro-explosions occur. The heated material is removed. This process is used for marking components or generating mechanical stresses in glass tubes to subsequently break them in a melting zone.

In DE 40 33 255 A1 a method is described that is designed to upgrade wood veneers for visual effect by emphasizing the grain. This is reached by pyrolytic browning of the wood surface using IR-radiation. The alterations following the laser cutting of wood and wood materials were investigated, among others, by Parameswaran, N.: Feinstrukturelle Veränderungen an durch Laserstrahl getrennten Schnittflächen von Holz und Holzwerkstoffen (Fine-structural alterations of laser-cut surfaces of wood and wood materials), Holz als

Roh- und Werkstoff, Berlin 40(1982)11, pp. 421–428, who found the following. The brown to black color of the cutting surfaces is due to the mainly thermal cutting process and typical of a pyrolysis in the cellular areas of separating. A surface largely melted down is produced, which very much reduces the diameters of the cell lumina. The high temperatures in the cutting kerf (approx. 700 °C, Arai et al. 1979) lead to a gradual transformation of the wall components into a glassy body. Back, E.L.: Cellulose bei hohen Temperaturen: Selbstvernetzung... (Cellulose at high temperatures: self-cross-linking...), Das Papier, 27(1973), pp. 475–483, theoretically determined the melting temperature of cellulose of approx. 450 °C based on the glass temperature. Further, he found that melting without pyrolytic side effects will only be possible if heating and cooling occur in a sufficiently short period of time.

The above-mentioned melting processes when processing wood are considered to be adverse side effects. To date, no alterations of specific wood properties has been created.

In addition to the typical pyrolytical degradation processes when wood is laser-processed, melting is also known as a secondary transformation process. As a rule, melted areas are considered negative concerning the quality of the wood surface processed. Additionally, the pyrolytical degradation products generated in processing are held and solidified in the melt. Known methods, such as laser

dividing, are generally confined to evaporating wood substance by thermal or photochemical coupling of the laser during processing. Thereby, the alteration of the wood structure in the areas adjacent to the processing zone is arbitrary. Degradation processes are not controllable, can hardly be avoided, and lead to a reduced quality of the wood processed in this way. Different methods, such as plasma processing (DE 41 35 697 A1), require much effort to prepare the wood and complicated jigs, which prevents the industrial-scale application.

It is the objective of this invention to describe a wood component as well as a method for the production and application of said component, in which, in geometrically defined areas, the wood has altered properties such that chemically and physically, systematically altered properties of the wood surface follow. The purpose is to avoid any treatment of the wood surface otherwise necessary, and to open a number of new possible uses and fields of application of wood.

SUMMARY OF THE INVENTION

According to the invention, the problem is solved using a wood component having altered properties of solidified wood melts substantially free from pyrolytic degradation products in geometrically defined near-surface areas.

A great number of component versions utilizing such structure represent several alternative embodiments. Further, the problem is solved using a process in which contact-free, short-time, high energy input is used to limit pyrolytic degradation processes. Versions of the process represent alternative embodiments of the method. Various applications of the component in accordance with the invention are contemplated.

The wood component has altered properties in geometrically defined areas. According to the invention, the geometrically defined areas have exclusively the properties of solidified wood melts. In the context of the various embodiments, it follows that said areas are single or several wood cells or single or several cell walls. From the melting together, alterations of properties of physical and chemical nature as well as tailored alterations of the deformation behavior follow.

According to further embodiments of the invention, the melt can be used for the production of joints of wood components and/or wood particles, or, respectively, reinforcements can be incorporated into the melt.

The main constituents of wood, cellulose, lignin and hemicelluloses, similar to other polymers have no melting point but there is a wide transition interval in phase transformation. In contrast to plastics, wood has no homogeneous structure and, hence, no softening point but a softening temperature

range. In wood, thermal degradation processes already start at temperatures lower than 100 °C. However, the critical factor for the beginning and progress of pyrolysis is the duration of heat influence, since pyrolysis is a continuous course of successive degradation processes. Softening starts at temperatures about 100 °C, progressing with a quickly decreasing degree of polymerization of the chains and beginning plasticization. Molten wood is characterized in that it has a low degree of polymerization, increased proportion of amorphous substance, lost fibrillar structure of the cellulose and typical cell structure, homogenization and increased melting temperature when repeatedly heated.

Accordingly, an embodiment of the invention directed to a method for the production of wood components is established such that the geometrically defined areas are melted by contact-free, short-time, preferably within less than or equal 50 ms, high energy input, so that the degree of polymerization of the chains decreases quickly and plasticization begins, and the melt solidifies within this period of time.

Advantageously, laser light is used as the electromagnetic radiation. The scope of the interaction zone, the interaction period and the intensity are realized by a combination of the relative movement between beam and workpiece as well as through methods of dynamic beam forming. Processing is in a gas atmosphere defined by composition, pressure and temperature. Heating can be in an inert gas

atmosphere as well as in free atmosphere. The process of the invention can be combined with other methods of woodworking, e.g. mechanical processing. Melting can be used within a defined time regime shortly before, during, or shortly after processing using another method.

From the invention, the following advantages result. Melting makes it possible to change the structure of wood. Closing the wood cells directly leads to a decrease of the specific surface, and the capillary take-up of humidity is reduced, or prevented, respectively. Wood and wood particles can be joined with each other by welding without any, or using solely wood-inherent (e.g. lignin) filling materials. By melting, wood can be joined with other materials, especially transparent polymers or fibrous materials. Melting is possible in a locally limited space or on a complete surface, whereby the proportion of melted volume has a geometrically defined magnitude on or below the surface, thus also defining the degree of alteration of physical and/or chemical properties. By melting, tailored physical and/or chemical alterations are produced in the wood. To realize this, also extraneous substances can be melted into the wood. Said extraneous substances can be particles and/or pigments. Before the melting process, they are applied into or onto the wood through, for example, impregnating, immersing, coating, or during the melting process, for example, by means of a gas or powder beam. The diffusion properties of the wood to ambient media are changed. The

diffusion properties in the main cutting directions of the wood are essentially homogeneous in melted areas. Melting leads to hydrophobing of the wood surface. Due to the tailored physical and/or chemical alterations, melted wood has an improved resistance to wood pest. Hardness and abrasion resistance of the wood surface can be adjusted. The optical properties (absorptivity, reflectivity and diffusing power) of the wood surface are deliberately altered. The lustre of melted wood is clearly different from that of unmelted wood. Softening of wood substance in the range of glass temperature offers novel possibilities for the deformation of wood.

In the following, the invention is further explained by examples of embodiment, read in conjunction with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an explanatory view of the manner of production of a wood component in accordance with an embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In order to protect the end of an 8 cm x 10 cm cross-sectioned wood beam from capillary water absorption, a closed surface of melted wood with a maximum thickness of 0.5 mm was produced in the range of the cross-cut grain. To produce this melted area the laser beam of a continuous CO_2-laser with a power of 2500 W and a laser spot diameter of 6 mm was meandered over the cross-cut surface to be processed of the beam end using a double-mirror scanner 1, with a track overlap of 10 percent and a velocity of 6 m/s.

In order to produce a homogeneous, closed melted zone with a thickness of more than 0.4 mm, the cell structure within the geometrically defined area must be abolished. Therefore, the wavelength and duration of the laser action were chosen such that the solid wood constituents were melted to a depth of approx. 0.8 mm.

The decreased capillary water absorption was evaluated by wetting with a defined water volume and measurement of the time until the complete penetration of the water. The investigation of the melted wood surface showed a penetration time prolonged by the factor 7.1.

As shown in Fig. 1, two spruce veneers 3 were welded together by melting of the lignin contained in the wood.

To this end, the veneers 3, first, were smoothed by ironing and fixed in a suitable fixture so that they lie close together without any clearance over the whole weld length.

To produce a weld 5, the laser beam 2 of a continuous CO_2-laser with a power of 2500 W, a spot diameter of 13 mm and a velocity of 12 m/s was linearly moved over the prepared weld area in a processing direction 4.

In order to produce a homogeneous closed weld 5 of a thickness of, at least, 0.5 mm, the cell structure within the geometrically defined area must be abolished. Therefore, the wavelength and duration of the laser beam 2 were chosen such that the solid wood constituents were melted to a depth of approx. 2 mm.

After processing, both veneers 3 are joined with each other by the weld 5. After separating the two veneers from each other, the microscope clearly shows a fracture edge over the whole weld length. Below the fracture edge a homogeneous melt layer 6 is observed. The cell structure is abolished down to a depth of 0.4 mm.